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ZnO-ZnS THIN FILM BY SCREEN PRINTING TECHNOLOGY FOR PHOTOVOLTAIC CELLS

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ABSTRACT

Thin-film solar cells using quantum dots would fill the future energy need. We know that the wide-band gap II–VI quantum dot semiconductor compounds such as ZnS and ZnO are widely used in optoelectronic devices, such as solar cells, sensors and in many. Printed electronics is a printing method used to create electrical and electronic devices on various substrates. Screen printing is one of the printed electronics method for fabricating electric and electronic devices due to its ability to produce patterned, thin layers from paste-like materials. This article discusses the trials in making thin films using screen printing technique with the quantum dots of ZnO- ZnS semiconductors which were already synthesised by simple solvo-thermal method and also explains how the films could be used in solar cells.

KEY WORDS: thin film, solar cell, ZnO-ZnS semiconductor quantum dot, printed electronics, screen printing.

Introduction

Cost-effective methods for very promising renewable energy technologies are a global need at present due to the depletion of conventional energy sources. Photovoltaic (PV) cells which are commonly called as solar cells are the best known devices for producing electric energy by converting solar energy into electricity directly. Solar cells produce current electricity directly from sun light which in turn used to power equipment or to recharge a battery. Bell Laboratories in 1551 first designed and fabricated a PV cell.[1,2]. But recently, numerous studies have reported the notable progress in PV cells design and performance for terrestrial applications [2-4]. Researchers are interested in thin-film solar cells, such as dye-sensitized solar cells, organic photovoltaics and colloidal nanocrystal solar cells,[5] because of the challenges with low-cost materials and cost-effective manufacturing methods. Also they are considered as very promising renewable energy technologies. We hope that the difficulties we face now in producing solar cells at present such as size, cost and energy efficiency would be over come in near future with quantum dot (QD) structures. They are neither atomic nor bulk semiconductor, but may best be described as artificial atoms. They present the utmost challenge in rendering photovoltaic devices such as solar cells and sensors. Thin-film technology using quantum dots in fabricating solar cells would fulfil the global energy need in future as the Quantum-dot-sensitized solar cells (QDSCs) have emerged as a promising candidate for the third-generation solar cells with the help of cost effective, simple procedures and incorporation of less-demanding materials.[6] As important wide band gap semiconductors, ZnO and ZnS are particularly interesting for applications in solar cells.[7] They are widely used in solar cells due to its high electrochemical stability and high electron mobility.[8]

Printing technologies such as screen printing, flexography, gravure, offset lithography, and inkjet are used in printed electronics to create electrical devices on various substrates such as glass, leather and plastic etc. Usually electrically functional optical inks or materials are deposited on the substrate, creating active or passive devices, such as thin film transistors; capacitors; coils; resistors. As printed electronics uses low-performance electronics, it is a cost effective method for various applications in solar cells, flexible displays, smart labels, decorative and animated posters, and active clothing. [9] Screen printing is an enabling technology for digital fabrication of thin-film. [10] For the first time the synthesised ZnO, ZnS, $ZnO_{0.5}S_{0.5}$ semiconductor nanomaterials are screen printed on different substrates in the scope of fabricating solar cells. The method is discussed in this article.

Materials and Method

ZnO, ZnS, $ZnO_{0.5}S_{0.5}$ semiconductor nanomaterials are synthesised using simple solvothermal method in a domestic micro-oven by adopting Mahadevan's method [11,12]. The particle size of the nanomaterials synthesised are less than 30nm for ZnO, 20nm for ZnS and $ZnO_{0.5}S_{0.5}$ nanoparticles. Also they all show blue shift which satisfies the quantum confinement. Surface patterning fabrication is a prerequisite step to synthesize practical devices. Thin film technology is one among many in the fabrication of the solar cells. Quantum Dot Thin Films (QDTFs) which can absorb and convert harmful UV light to usable visible light. Also the QDTFs solar cells can expand the photo response range and enhance the photoelectric conversion efficiency. Thereby, QDTFs have high potential for applications in thin film solar cells.[13] Formation of thin film from the quantum dots synthesised is really a challenging task.

ScreenPrinting is one of the ablest technology for the formation of the film. We could easily perform this in a print shop, lab environment or even at home. We could use any sort of substrates which include PET film, office paper, leather, metal, stone, and wood. The procedure is explained as follows.

Fabrication Process: How to print

The glass slides of 2mm thickness and of dimension 5x 2 cm are taken. The glass slides are washed with water and soap. Then the slides are soaked in HCl solution for 24 hours. T he slides are then cleaned with acetone and dried for further use. PET films also cut and wiped with acetone. The quantum dots are taken in small quantity (say0.02g) in a watch glass. A thin dry white ink deposit(5019 gold medium) which has high optical density, excellent boiling water resistant and high temperature resistance is used for the adhesion. Both the medium and the quantum dots are mixed together thoroughly to make a paste. A 120 µm segmented nylon mesh is used as the screen in printing. At most care is taken for the purity in making the matrix. A small portion of the paste is squeezed over the substrates with printing angle of 45˚ to make a clear film. Eventually, the printed layer was cured in the atmospheric air. In the printing process, material specifications, clearance of the substrates, squeegee angle, printing speed, adherent ink properties, and pressure are the key factors which determine the quality of printed layers

Fig. 1 shows schematic diagram of the basic elements, mask design, and fabrication process of screen printing.

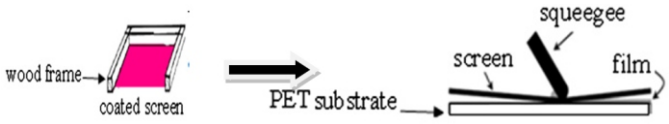
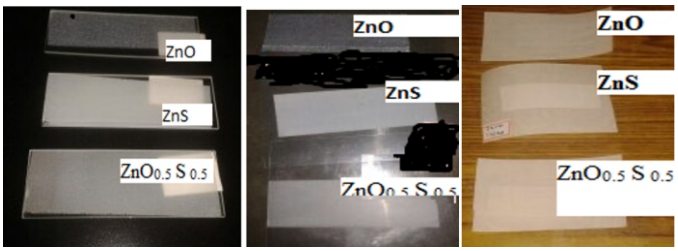


Fig 1 Schematic Diagram of the Screen Printing Technology

Fig 2 shows the final products of Zno, ZnS, $ZnO_{0.5}S_{0.5}$ quantum dots on the substrates like glass and PET films



(A) On Glass **(B) On PET film** **(C) On Sticker film**

Fig :2 Zno, ZnS, $ZnO_{0.5}S_{0.5}$ quantum dots on the substrates

Integration with Printed Electronics

At present the Printed electronics is becoming a powerful and affordable technology for fabricating functional devices. The Print Screen, could be used as a versatile platform which enables even non-expert users to design and fabricate highly customized flexible interactive displays which are technically based on thin-film electroluminescence. [10] Also the films can be used in sensor

applications for detection of the gases with the properties of both reducing and oxidizing. [14,15] Another greater advantage of this technique it offers the advantage of low-cost production, and can be used to print the front and back contacts of Si solar cells, and in other types of photovoltaic cells.[16]

Discussion And Limitations

The Quantum Dot Thin films produced by the Print Screen method use an easy method for device fabrication. Only a few trials could make anybody expert in this work. Steady hand for a uniform pressure is only required to produce fine prints on the film substrates. Safety measures such as wearing rubber gloves, goggles have to be taken to protect the hands and the eyes while producing the QDFTs. Once when the films are cured, the display is safe to interact with. To the understanding the Print Screen could be the only solution for designers, makers and experts that allows direct integration of devices with various base substrates.

Conclusion

Print Screen is an enabling technology for digital fabrication of customized thin-films. From our experiments it is clear that we could prepare the QDTFs using simple, cost effective Screen Printing Technology and the same could be used in the device fabrication in near future. The characterisation of the thin films are to be done in future for making further fine structures for the fruitful electric and electronic devices.

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REFERENCES

1. High efficiency Design and Efficiency Enhancements ,Green, M. A.: *Silicon Solar Cells: Evolution, Semiconductor Science Technology*, 1993, vol. 8, pp. 1-12.
2. A Brief History of the First 50 Years, Progress in Photovoltaics : Green, M. A.: *Silicon Photovoltaic Modules:Research and Applications*, 2005, vol.13, pp. 447- 455.
3. Solar Cell Efficiency Tables (Version 27): Green, M. A.; Emery, K.; King, D. L.; Hisikawa, Y.; Warta, W.: *Progress in Photovoltaics: Research and Applications*, 2006, vol. 14, pp. 45- 51.
4. Solar Cell Efficiency Tables (Version 28): Green, M. A.; Emery, K.; King, D. L.; Hisikawa, Y.; Warta, W.: *Progress in Photovoltaics: Research and Applications 2006*, vol. 14, pp. 455 – 461.
5. Large Perovskite Grain Growth in Low Temperature Solution- Processed Planar p-i-n Solar Cells by Sodium Addition: Santanu Bag and Michael F. Durstock *ACS Appl. Mater. Interfaces*, 10 Feb 2016
6. Harvesting Light Energywith Cdse/ Cdse(Silar) /Zns (Silar) Nanocrystals Molecularly Linked To Mesoscopic Tio2 Films For Quantum Dot Solar Cells: H. T. Tung *International Journal of Latest Research in Science and Technology, Volume 3, Issue 6: Page No.33-36, November-December 2014*
7. Quantum Dots and Their Multimodal Applications: A Review Debasis Bera, Lei Qian, Teng-Kuan Tseng and Paul H. Holloway, *Materials 2010, 3, 2260-2345*
8. Coaxial Silicon Nanowires as Solar Cells and Nanoelectronic Power Sources Tian, B.; Zheng, X.; Kempa, T. J.; Fang, Y.; Yu, N.; Yu, G.; Huang, J.; Lieber, C. M. *Nature* **2007**, *449*, 885–890.
9. ZnS/ZnO heterojunction as photoelectrode: Type II band alignment towards enhanced photoelectrochemical performance Penghui Guo, Jiangang Jiang, Shaohua Shen, Liejin Guo *International Journal of Hydrogen Energy* (2013)
10. PrintScreen: Fabricating Highly Customizable Thin-film Touch-Displays Simon Olberding, Michael Wessely, Jürgen Steimle *UIST'14, October 5–8, 2014, Honolulu, HI, USA*
11. Luminescence Properties of ZnS-ZnO Nanocomposites Synthesized by Solvothermal Method. G.Janita Christobel and C.K.Mahadevan Proceedings of the "International Conference on Advanced Nanomaterials & Emerging Engineering Technologies" 978-1-4799-1379-4/13/$31.00 ©2013 IEEE
12. Vibrational Spectroscopy of ZnO-ZnS Nanoparticles **G**. *Janita Christobel, International Journal of Science and Research ,Volume 5 Issue 6, June 2016,2228-2230*
13. Single-step direct fabrication of luminescent Cudoped ZnxCd1_xS quantum dot thin films via amolecular precursor solution approach and their application in luminescent, transparent, and conductive thin films Yanyan Chen, Shenjie Li, Lijian Huang and Daocheng Pan*Nanoscale, 2014, 6, 9640
14. D. Gruber, F. Kraus and J. Müller, "A Novel Gas Sensor Design Based on CH4/H2/H2O Plasma Etched ZnO Thin Films," *Sensors and Actuators B*: *Chemical*, Vol. 92, No. 1-2, 2003, pp. 81-89.
15. Zinc Oxide Nanostructure Thick Films as H2S Gas Sensors at Room Temperature: Vinod S. Kalyamwar, Fulsingh C. Raghuwanshi, Narayan L. Jadhao, Anil J. Gadewar *Journal of Sensor Technology*, 2013, 3, 31-35
16. Ag–Al alloythinfilmon plastic substrate by screen printing for solarcell backcontactapplication M.K.M. Ali et al. / Materials Science in Semiconductor Processing 16 (2013) 593–597